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Hattori

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(54) IMAGE FORMING DEVICE THAT PERFORMS DENSITY DETECTION

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(51) **Int. Cl.**
G03G 15/00 (2006.01)

(52) **U.S. Cl.** **399/49**; 399/72

(58) **Field of Classification Search** 399/49, 399/66, 72, 299, 302
See application file for complete search history.

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(74) *Attorney, Agent, or Firm*—Oliff & Berridge, PLC

(57) **ABSTRACT**

During a first rotation of a photoconductor, latent electrostatic images for color correction processing patterns are formed on the photoconductor, and the latent electrostatic images are developed into the color correction processing patterns in each of four colors, and then densities of the patterns on the photoconductor are detected. During a second rotation of the photoconductor, each color of the patterns is recovered back into a developer device.

4 Claims, 7 Drawing Sheets

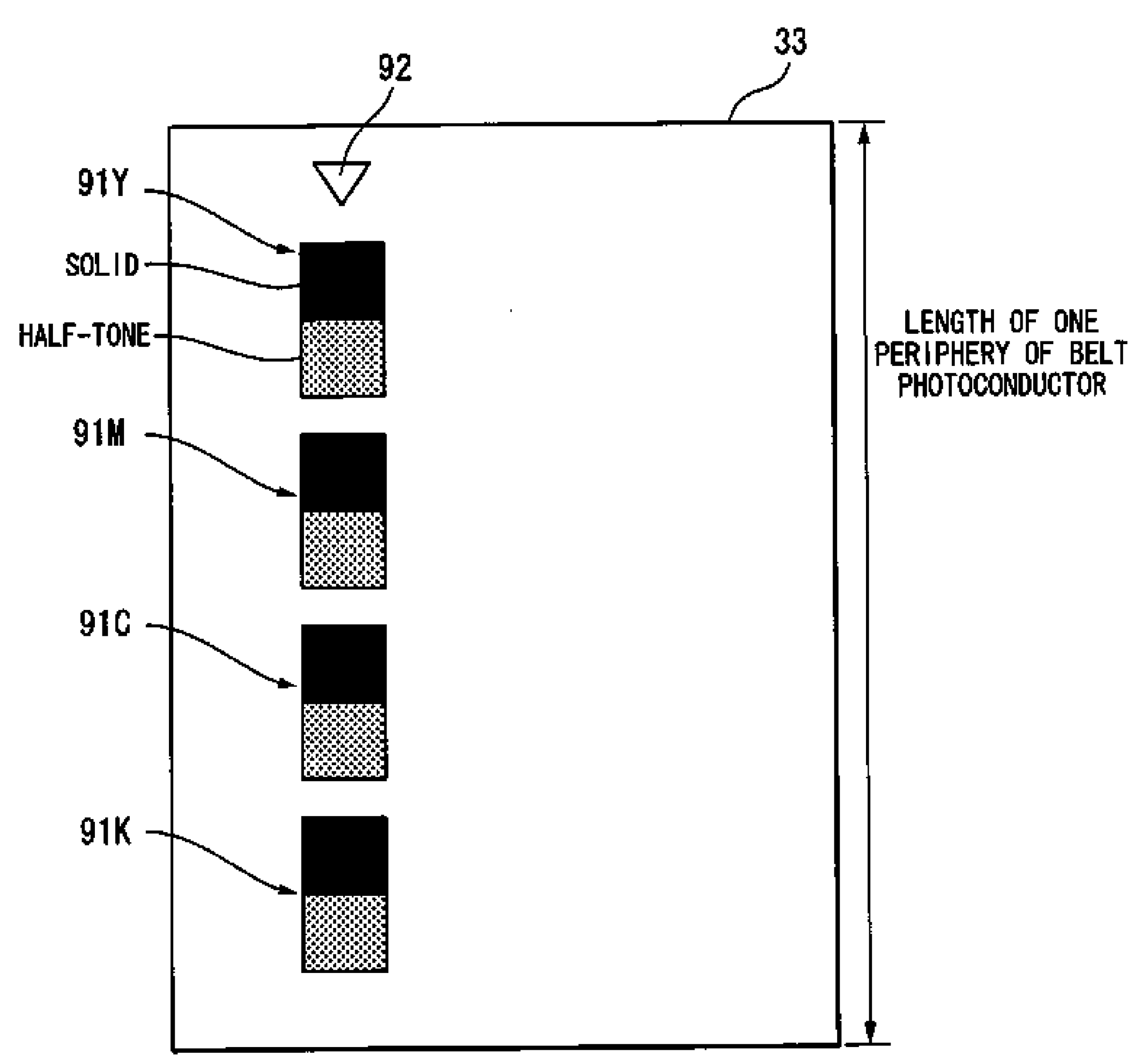

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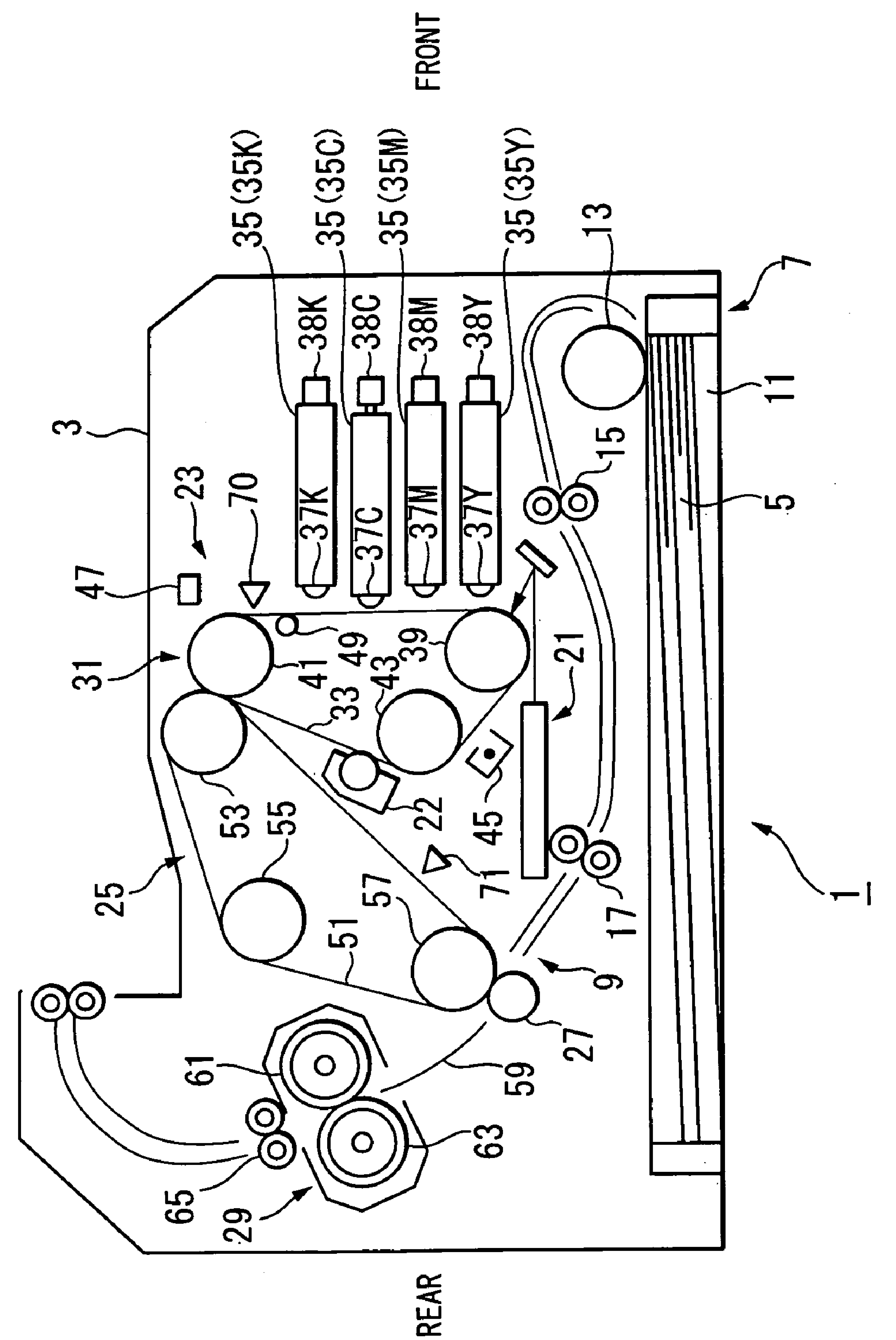
FIG. 1


FRONT
REAR
35 (35K)
35 (35C)
35 (35M)
35 (35Y)
38K
38C
38M
38Y
37K
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37M
37Y
3
23
70
47
31
41
49
43
39
33
21
22
45
53
55
25
57
71
51
9
17
27
59
61
63
65
29
13
11
15
5
7
1

FIG. 2

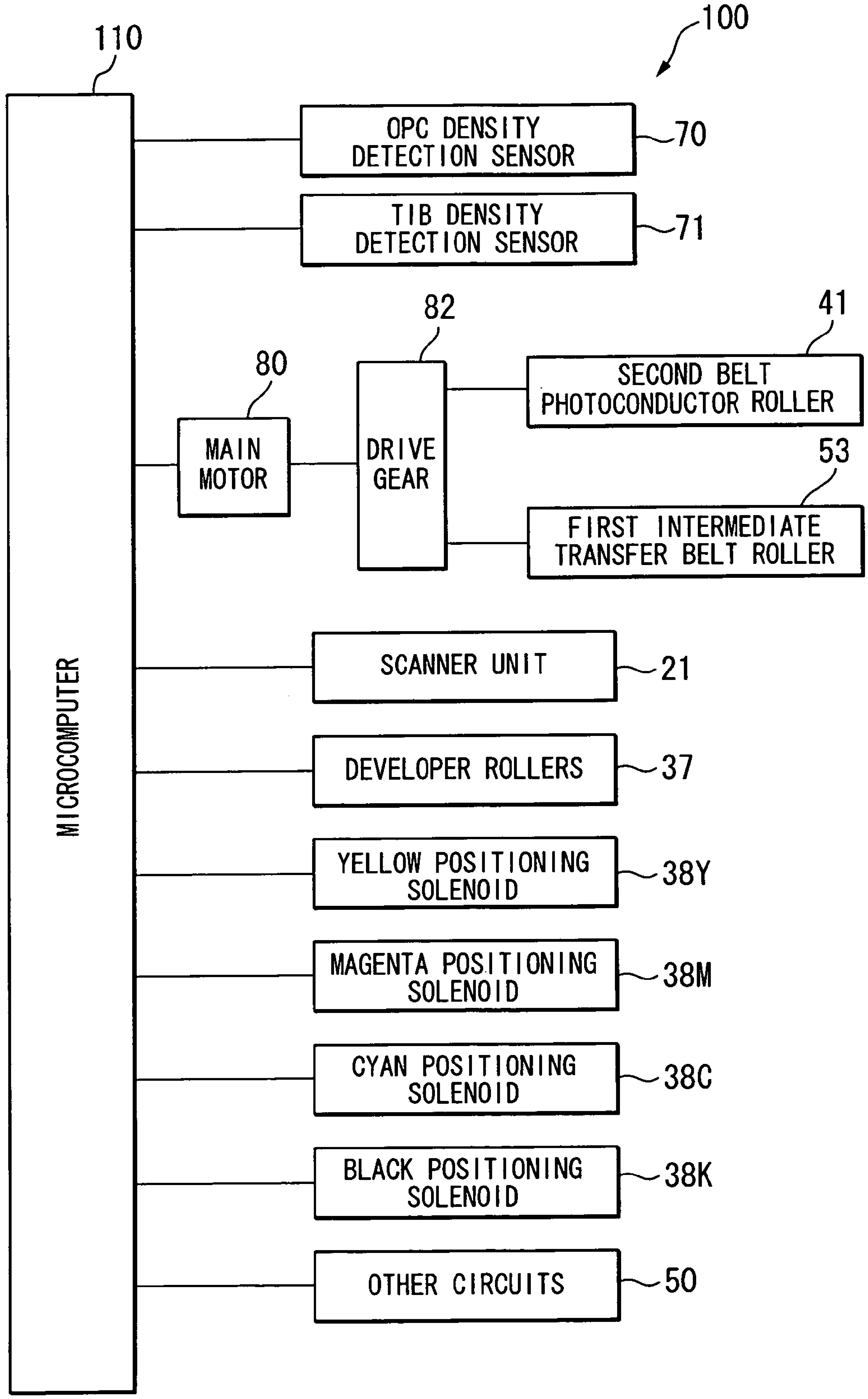
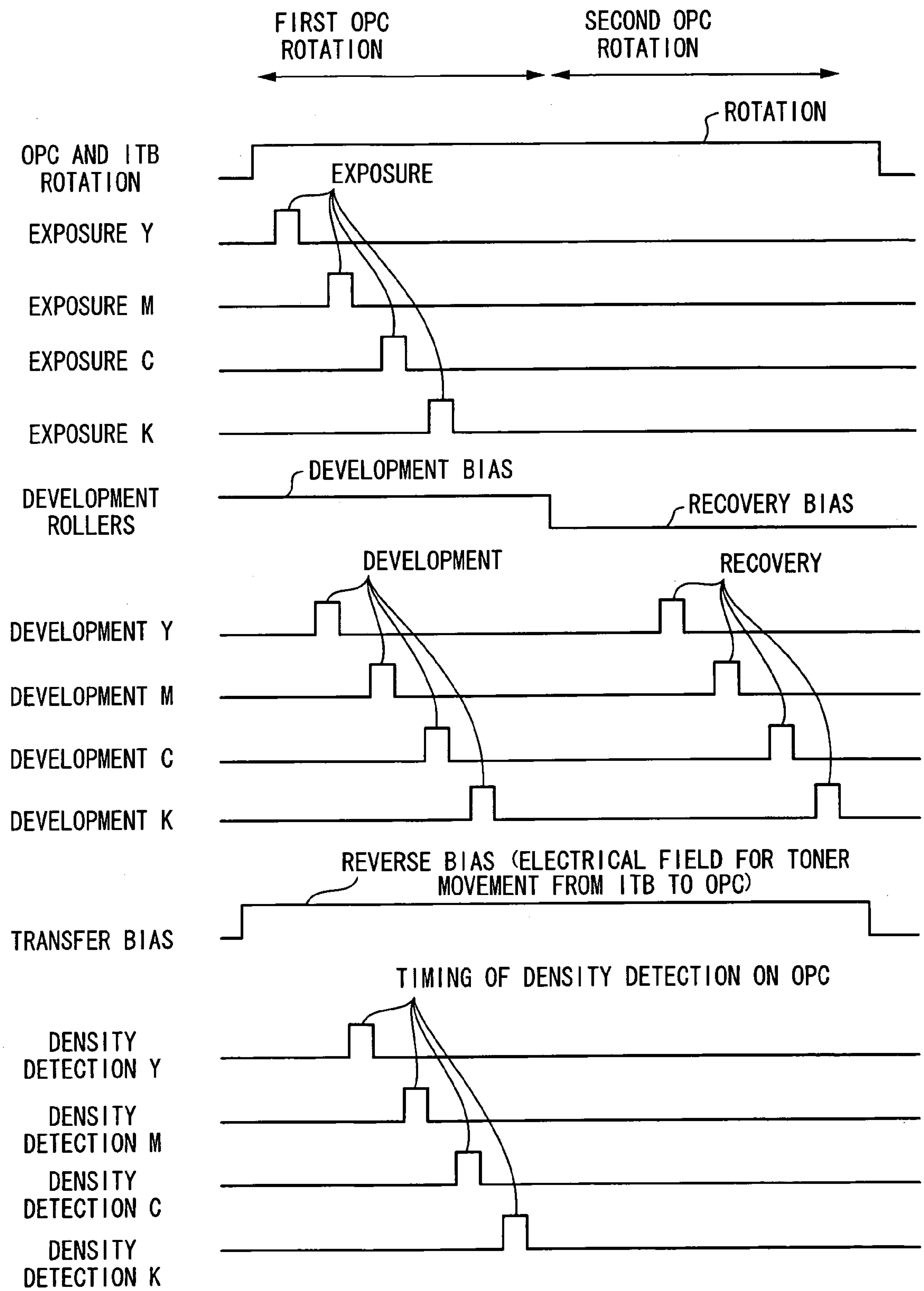

100
110
MICROCOMPUTER
OPC DENSITY DETECTION SENSOR
70
TIB DENSITY DETECTION SENSOR
71
82
41
80
SECOND BELT PHOTOCONDUCTOR ROLLER
MAIN MOTOR
DRIVE GEAR
53
FIRST INTERMEDIATE TRANSFER BELT ROLLER
SCANNER UNIT
21
DEVELOPER ROLLERS
37
YELLOW POSITIONING SOLENOID
38Y
MAGENTA POSITIONING SOLENOID
38M
CYAN POSITIONING SOLENOID
38C
BLACK POSITIONING SOLENOID
38K
OTHER CIRCUITS
50

FIG. 3



FIRST OPC ROTATION
SECOND OPC ROTATION
ROTATION
OPC AND ITB ROTATION
EXPOSURE
EXPOSURE Y
EXPOSURE M
EXPOSURE C
EXPOSURE K
DEVELOPMENT BIAS
DEVELOPMENT ROLLERS
RECOVERY BIAS
DEVELOPMENT
RECOVERY
DEVELOPMENT Y
DEVELOPMENT M
DEVELOPMENT C
DEVELOPMENT K
REVERSE BIAS (ELECTRICAL FIELD FOR TONER MOVEMENT FROM ITB TO OPC)
TRANSFER BIAS
TIMING OF DENSITY DETECTION ON OPC
DENSITY DETECTION Y
DENSITY DETECTION M
DENSITY DETECTION C
DENSITY DETECTION K

FIG. 4

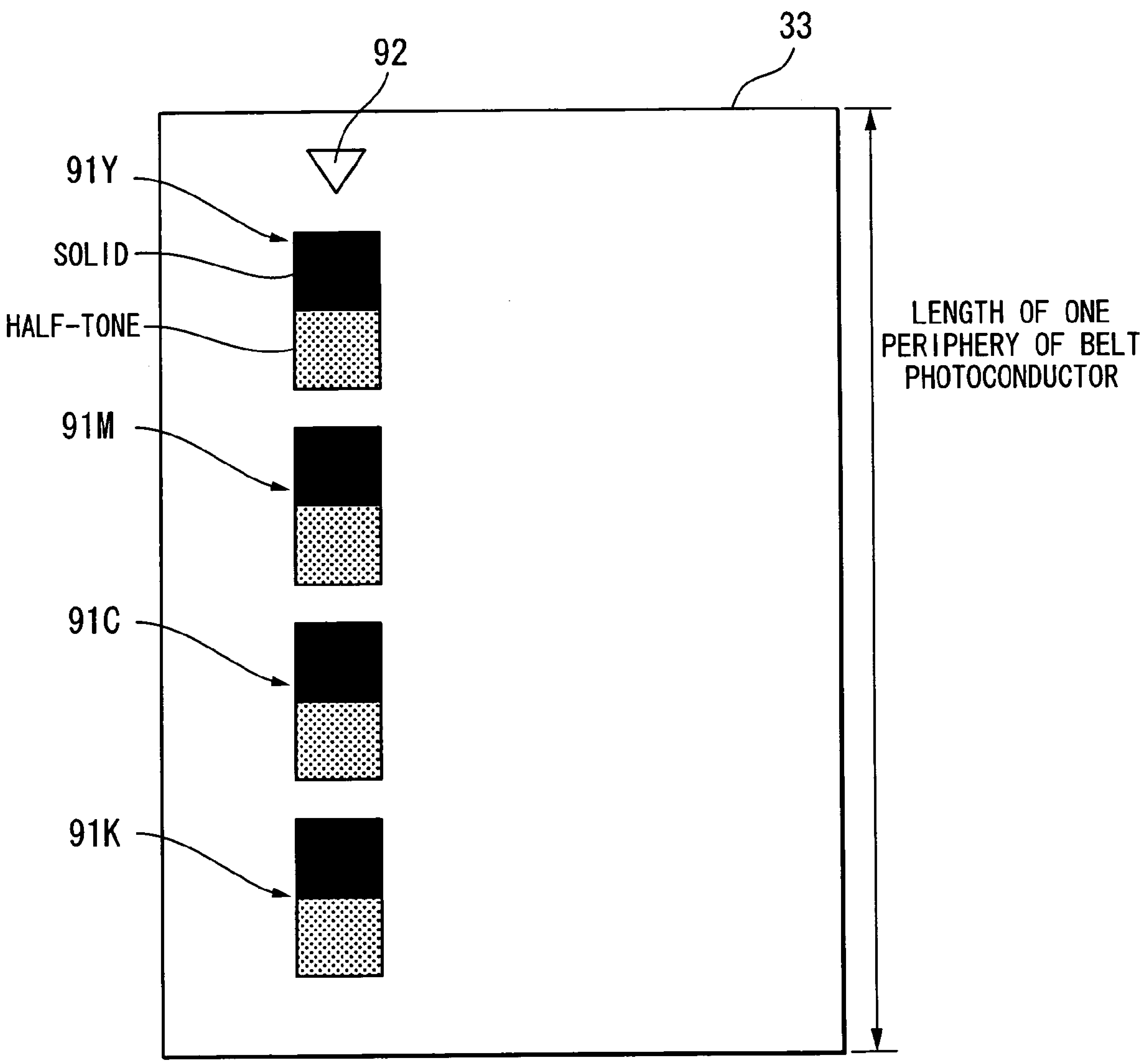
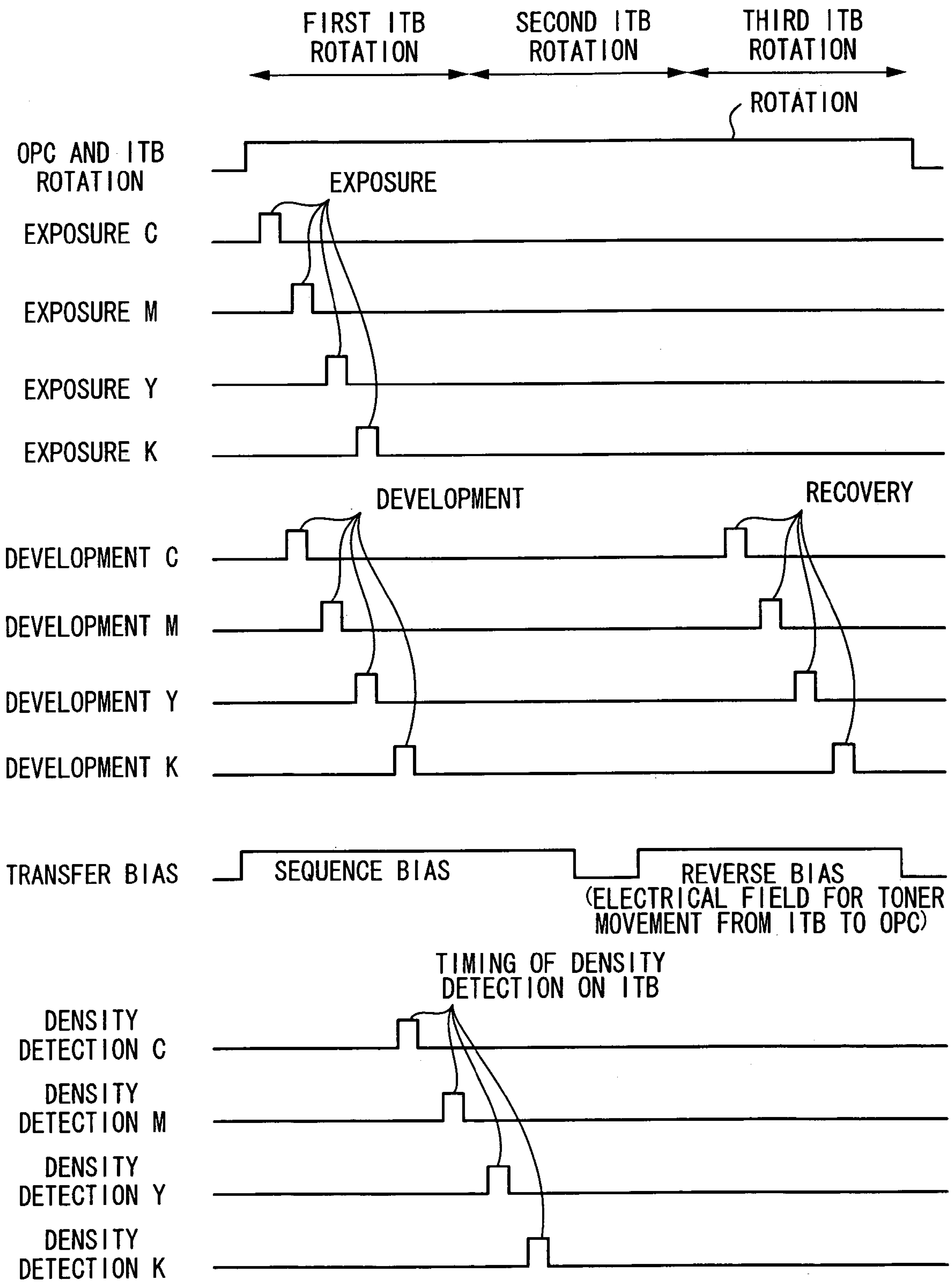
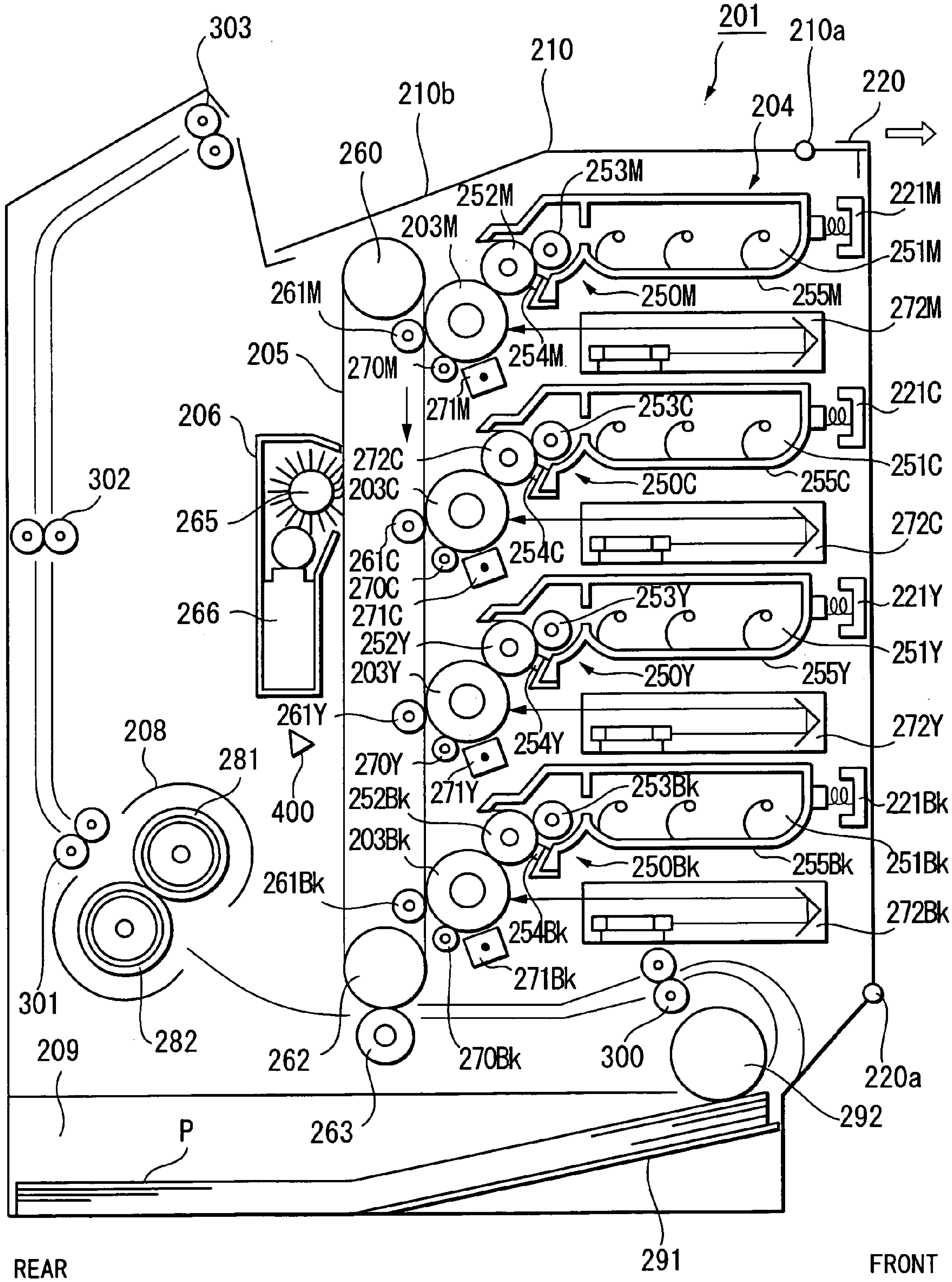

33
92
91Y
SOLID
HALF-TONE
91M
91C
91K
LENGTH OF ONE PERIPHERY OF BELT PHOTOCONDUCTOR

FIG. 5



FIRST ITB ROTATION
SECOND ITB ROTATION
THIRD ITB ROTATION
ROTATION
OPC AND ITB ROTATION
EXPOSURE
EXPOSURE C
EXPOSURE M
EXPOSURE Y
EXPOSURE K
DEVELOPMENT
RECOVERY
DEVELOPMENT C
DEVELOPMENT M
DEVELOPMENT Y
DEVELOPMENT K
TRANSFER BIAS
SEQUENCE BIAS
REVERSE BIAS (ELECTRICAL FIELD FOR TONER MOVEMENT FROM ITB TO OPC)
TIMING OF DENSITY DETECTION ON ITB
DENSITY DETECTION C
DENSITY DETECTION M
DENSITY DETECTION Y
DENSITY DETECTION K

FIG. 6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251Y
203Y
250Y
255Y
261Y
208
272Y
281
254Y
270Y
271Y
253Bk
252Bk
221Bk
400
203Bk
251Bk
250Bk
255Bk
261Bk
272Bk
254Bk
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282
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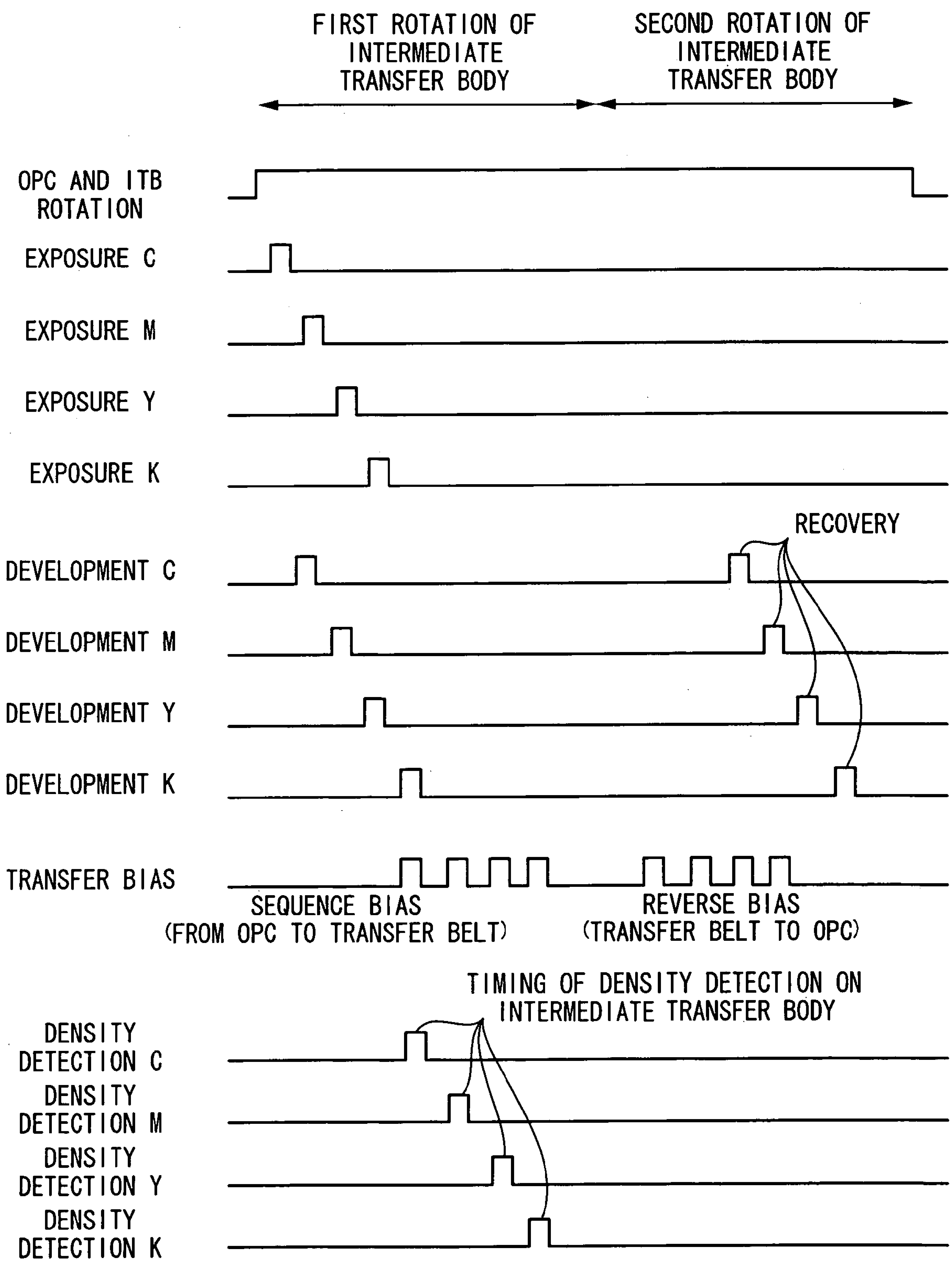
262
270Bk
300
220a
292
P
263
291
REAR
FRONT

FIG. 7



FIRST ROTATION OF INTERMEDIATE TRANSFER BODY
SECOND ROTATION OF INTERMEDIATE TRANSFER BODY
OPC AND ITB ROTATION
EXPOSURE C
EXPOSURE M
EXPOSURE Y
EXPOSURE K
RECOVERY
DEVELOPMENT C
DEVELOPMENT M
DEVELOPMENT Y
DEVELOPMENT K
TRANSFER BIAS
SEQUENCE BIAS (FROM OPC TO TRANSFER BELT)
REVERSE BIAS (TRANSFER BELT TO OPC)
TIMING OF DENSITY DETECTION ON INTERMEDIATE TRANSFER BODY
DENSITY DETECTION C
DENSITY DETECTION M
DENSITY DETECTION Y
DENSITY DETECTION K

IMAGE FORMING DEVICE THAT PERFORMS DENSITY DETECTION

This is a Division of application Ser. No. 10/813,303 filed Mar. 31, 2004 now U.S. Pat. No. 7,099,600. The disclosure of the prior application is hereby incorporated by reference herein in its entirety.

BACKGROUND

The present invention relates to an image forming device that employs an electrophotographic method using developers of a plurality of colors and, in particular, to an image forming device that detects color densities to perform color correction process.

It is known in the art for a color laser printer to detect the densities of different colors and perform color correction based on the detection results (for example, Japanese Patent Application Publication No. 2001-201904).

A typical color laser printer uses a method known as the four-cycle printing method, wherein a multicolor image is formed on an image-support member by four rotations of a photoconductor such that a monochromatic toner image is formed at each rotation of the photoconductor, and then the multicolor image on the image support member is transferred to a recording medium. When performing the density detection for each color in this printer, the photoconductor rotates four times in the same manner as during printing. Therefore, the density detection necessitates at least four rotations of the photoconductor, which takes too long a time.

In this four-cycle printing type of laser color printer, or in a tandem-style color laser printer in which one photoconductor is provided for each color, all of the toner used during density detection is discarded, which is a waste.

These problems are not limited to color laser printers, but occur in other image forming devices also.

SUMMARY OF THE INVENTION

It is an object of the present invention to overcome the above problems and also to provide an image forming device that enables efficient density detection.

In order to attain the above and other objects, according to one aspect of the present invention, there is provided an image forming device including a photoconductor that moves, an exposure unit that forms a latent electrostatic image on the photoconductor, a developing unit that develops the latent electrostatic image into a developer image, the developer unit being provided for each of a plurality of colors, an image support member that supports the developer image, a first transfer member that transfers the developer image from the photoconductor to the image support member, a second transfer member that transfers the developer image from the image support member onto a recording medium, a controller that controls the exposure unit and the developing unit, and a density detector that detects a density. While the exposure unit forms a first latent electrostatic image corresponding to a first developer image of each of the plurality of colors and the developing unit develops the first latent electrostatic image into the first developer image, the photoconductor moves by a first amount, the first developer image corresponding to a maximum printable size of the recording medium. The controller controls the exposure unit and the developing unit to form a second latent electrostatic image corresponding to a second developer image and to develop the, second latent electrostatic image into the second developer image of each of the plurality of colors while the photoconductor moves by a second amount less than the first amount. The second developer image is for color correction process. The density detector detects the density of the second developer image.

For example, if the maximum printable size of the recording medium is A3 and the minimum printable size of the recording medium is B5, then the first amount is an amount necessary for forming a developer image corresponding to A3 size, and the second amount could be an amount that is necessary for forming a developer image corresponding to B5 size.

According to another aspect of the present invention, there is provided an n image forming device including a plurality of photoconductors each corresponding to one of a plurality of colors, a plurality of exposure units each corresponding to one of the plurality of colors, each of the exposure units forming a latent electrostatic image on the corresponding one of the photoconductors, a plurality of developing units each corresponding to one of the plurality of colors, each of the developing units developing the latent electrostatic image formed on the corresponding one of the photoconductors into a developer image, an image support member that supports a developer image, a transfer unit that transfers the developer images each developed by one of the developing units onto the image support member, and a density detector that detects a density of a developer image. During printing, the transfer unit transfers the developer images in each of the plurality of colors such that the developer images are superimposed on the on the image support member thereby to produce a multicolor image. During density detection, the transfer unit transfers the developer images in each of the plurality of colors to mutually different positions of the image support member, and the density detector detects the density of each developer image supported on the image support member.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. **1** is a schematic view of a color laser printer according to a first embodiment of the present invention;

FIG. **2** is a block diagram of the color laser printer of FIG. **1**;

FIG. **3** is a timing chart illustrating a first density detection operation according to the first embodiment;

FIG. **4** is illustrative of color correction processing patterns;

FIG. **5** is a timing chart illustrating a second density detection operation according to the first embodiment;

FIG. **6** is a schematic view of a color laser printer according to a second embodiment of the present invention; and

FIG. **7** is a timing chart illustrating a density detection operation according to the second embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Image forming devices according to embodiments of the present invention will be described with reference to the attached drawings. In a first embodiment, a four-cycle printing type of color laser printer is used as an example of the image forming device.

A color laser printer **1** according to the first embodiment of the present invention will be described with reference to FIGS. **1** to **5**.

As shown in FIG. **1**, the color laser printer **1** includes a sheet supply portion **7**, an image forming portion **9**, and a main casing **3** that houses the sheet supply portion **7** and the image forming portion **9**. The sheet supply portion **7** is for supplying a recording sheet **5**, and the image forming portion **9** is for forming a predetermined image onto the recording sheet **5** supplied from the sheet supply portion **7**.

The sheet supply portion **7** is provided with a sheet supply tray **11**, a sheet supply roller **13**, feed rollers **15**, and register rollers **17**. The sheet supply tray **11** accommodates a stack of recording sheets **5**. The sheet supply roller **13** contacts the uppermost recording sheet **5** in the sheet supply tray **11** and extracts the recording sheets **5** one at a time by the rotation thereof. The feed rollers **15** and the register rollers **17** feed the recording sheet **5** to an image forming position.

The image forming position is a transfer position at which a toner image on an intermediate transfer belt (ITB) **51** (described later) is transferred onto the recording sheet **5**. In this embodiment, the image forming position is a position at which the intermediate transfer belt **51** comes into contact with a transfer roller **27** (described later).

The image forming portion **9** includes a scanner unit **21**, a process portion **23**, an intermediate transfer belt mechanism **25**, the transfer roller **27**, and a fixer portion **29**.

The scanner unit **21** includes a laser generation portion, a polygon mirror, a plurality of lenses, and reflective mirrors (not shown in the drawings) in a central portion within the main casing **3**. In the scanner unit **21**, a laser beam that is generated from the laser generation portion on the basis of image data is transmitted or reflected through the polygon mirror, the reflective mirrors, and the lenses, and scans at a high speed across a surface of a belt organic-photoconductor (OPC) **33** of a belt photoconductor mechanism **31** (described later).

The process portion **23** includes a plurality of developer cartridges **35** (four developer cartridges **35** in this embodiment) and the belt photoconductor mechanism **31**. The four developer cartridges **35** are a yellow developer cartridge **35**Y containing yellow toner, a magenta developer cartridge **35**M containing magenta toner, a cyan developer cartridge **35**C containing cyan toner, and a black developer cartridge **35**K containing black toner, disposed sequentially in a vertical row from bottom to top at a predetermined mutual spacing toward the front within the main casing **3**.

Each of the developer cartridges **35** includes a developer roller **37** (yellow developer roller **37**Y, magenta developer roller **37**M, cyan developer roller **37**C, black developer roller **37**K), a layer-thickness regulation blade, a supply roller, and a toner container portion (not shown). Each of the developer cartridges **35** can be moved in the horizontal direction by a corresponding one of positioning solenoids **38** (yellow positioning solenoid **38**Y, magenta positioning solenoid **38**M, cyan positioning solenoid **38**C, black positioning solenoid **38**K), so as to bring the developer roller **37** into contact with or away from the surface of the belt photoconductor **33**.

Each developer roller **37** includes a metal roller shaft covered with a roller that is formed of an elastic member of a conductive rubber material. The roller of the developer roller **37** is formed to have a two-layer structure including a roller portion and a coating layer that covers the surface of the roller portion. The roller portion is an elastic body formed of a rubber, such as urethane rubber, silicone rubber, or EPDM rubber, containing carbon particles or the like. The coating layer has a main constituent that is urethane rubber, a urethane resin, or a polyimide resin. A developer bias, which is a sequence bias, is applied to the developer roller **37** with respect to the belt photoconductor **33** during development, and a predetermined recovery bias, which is a reverse bias, is applied during recovery of the toner. For example, the predetermined developer bias is +300 V, and the predetermined recovery bias is −200 V.

A toner container portion of each developer cartridge **35** is filled with spherical, positively charging, non-magnetic, single component, polymerized toner as the developer for the corresponding color yellow, magenta, cyan, or black. During development, the toner is supplied to the developer roller **37** by the rotation of the supply roller and given a positive electrical charge by friction between the supply roller and the developer roller **37**. The toner on the developer roller **37** is introduced between the layer-thickness regulation blade and the developer roller **37** as the developer roller **37** rotates, where the toner acquires a further electrical charge by friction, so that a thin toner layer having a constant thickness is formed on the developer roller **37**. During recovery, the recovery bias is applied to the developer roller **37** so that toner is recovered from the belt photoconductor **33** and stored back into the toner container portion.

The belt photoconductor mechanism **31** includes a first belt photoconductor roller **39**, a second belt photoconductor roller **41**, a third belt photoconductor roller **43**, the photoconductor **33**, a belt photoconductor electrostatic charger **45**, a potential applicator **47**, and a potential gradient controller **49**. The configuration of the belt photoconductor mechanism **31** will be described later.

The intermediate transfer belt mechanism **25** is disposed to the rear of the belt photoconductor mechanism **31** and includes the intermediate transfer belt (ITB) **51**, a first intermediate transfer belt roller **53**, a second intermediate transfer belt roller **55**, and a third intermediate transfer belt roller **57**. The first intermediate transfer belt roller **53** is disposed substantially facing the second belt photoconductor roller **41** with the belt photoconductor **33** and the intermediate transfer belt **51** interposed therebetween. The second intermediate transfer belt roller **55** is disposed diagonally rearward from the first intermediate transfer belt roller **53**. The third intermediate transfer belt roller **57** is disposed rearward of the second intermediate transfer belt roller **55** and facing the transfer roller **27** with the intermediate transfer belt **51** interposed therebetween. The intermediate transfer belt **51** is looped around the rollers **53**, **55**, and **57**. The intermediate transfer belt **51** is an endless belt formed of a resin, such as an electrically conductive polycarbonate or polyimide, in which are dispersed conductive particles of a material, such as carbon.

That is, the rollers **53**, **55**, and **57** are disposed in a triangular arrangement with the intermediate transfer belt **51** wound therearound. The first intermediate transfer belt roller **53** is driven to rotate by the operation of a main motor **80** (see FIG. **2**) via a drive gear **82**, and the rollers **55** and **57** are driven to rotate as the first intermediate transfer belt roller **53** rotates, so that the intermediate transfer belt **51** moves circumferentially (in the clockwise direction) around the rollers **53**, **55**, and **57**.

The color laser printer **1** further includes an ITB density detection sensor **71** for detecting the density of a toner image of each color that has been formed on the intermediate transfer belt **51**. The ITB density detection sensor **71** includes a light source that emits light in the infrared region, a lens that irradiates the intermediate transfer belt **51** with the light, and a phototransistor that receives the light reflected from the intermediate transfer belt **51**.

The transfer roller **27** is rotatably supported and disposed facing the third intermediate transfer belt roller **57** with the intermediate transfer belt **51** sandwiched therebetween. The transfer roller **27** is formed of a metal roller shaft that is covered with a roller formed of an electrically conductive rubber material. A transfer roller separation/connection mechanism (not shown) moves the transfer roller **27** between a standby position that is separated from the intermediate transfer belt **51** and a transfer-enabling position in the vicinity of the intermediate transfer belt **51**. At the transfer-enabling position, the transfer roller **27** presses the recording sheet **5** against the intermediate transfer belt **51** as the recording sheet **5** passes along the feed path **59**.

During printing, the transfer roller **27** is placed at the standby position while toner images in each color are transferred sequentially to the intermediate transfer belt **51** as will be described later, and is moved to the transfer-enabling position when a multicolor image is formed on the intermediate transfer belt **51**, that is, when transfer of all the toner images from the belt photoconductor **33** onto the intermediate transfer belt **51** has completed. During color correction process, the transfer roller **27** is placed at the standby position.

The predetermined transfer bias with respect to the intermediate transfer belt **51** is applied to the transfer roller **27** by a transfer bias application circuit (not shown) when the transfer roller **27** is at the transfer-enabling position.

The fixer portion **29** is disposed to the rear of the intermediate transfer belt mechanism **25** and includes a heating roller **61**, a pressure roller **63**, and a pair of feed rollers **65**. The pressure roller **63** presses against the heating roller **61**, and the feed rollers **65** are provided on the downstream side of the heating roller **61** and the pressure roller **63** with respect to a sheet feed direction in which the recording sheet **5** is transported. The heating roller **61** has an outer layer of silicone rubber, an inner layer of metal, and a halogen lamp for heating.

The belt photoconductor mechanism **31** of the image forming portion **9** will be described in more detail. The first belt photoconductor roller **39** is disposed facing the rear of the four developer cartridges **35**, at a position lower than the yellow developer cartridge **35**Y that is the lowermost developer cartridge **35**. The first belt photoconductor roller **39** is a driven roller. The second belt photoconductor roller **41** is disposed above the first belt photoconductor roller **39**, at a position higher than the black developer cartridge **35**K which is the uppermost developer cartridge **35**. The second belt photoconductor roller **41** is driven to rotate by the main motor **80** via the drive gear **82**. The third belt photoconductor roller **43** is positioned to the rear of and diagonally above the first belt photoconductor roller **39**. The third belt photoconductor roller **43** is a driven roller. Thus, these rollers **39**, **41**, and **43** are disposed in a triangular arrangement.

The potential applicator **47** is disposed adjacent to the second belt photoconductor roller **41** and applies a predetermined potential to the second belt photoconductor roller **41**, using the power source of the belt photoconductor electrostatic charger **45**.

The first and third belt photoconductor rollers **39** and **43** are formed of electrically conductive members, such as aluminum. The first and third belt photoconductor rollers **39** and **43** are in contact with a foundation layer (described later) of the belt photoconductor **33** and also connected to a GND terminal (not shown). With this configuration, the first and third belt photoconductor rollers **39** and **43** maintain the potential of the belt photoconductor **33** at ground level at positions where the rollers **39** and **43** contact the foundation layer.

The belt photoconductor **33** is wound around the first to third belt photoconductor rollers **39**, **41**, and **43**. As the second belt photoconductor roller **41** rotates, the first and third belt photoconductor rollers **39** and **43** are driven to rotate, so that the belt photoconductor **33** rotates therearound (in the counterclockwise direction).

The belt photoconductor **33** is an endless belt having the foundation layer (an electrically conductive foundation layer) with a thickness of 0.08 mm and a photosensitive layer of a thickness of 25 μm formed on one side of the foundation layer. The foundation layer is made of a nickel conductor fabricated by a nickel electroforming method, and the photosensitive layer is made of a photoconductor of a polycarbonate resin.

The color laser printer **1** further includes an OPC density detection sensor **70** for detecting the density of toner images in each color that are formed on the belt photoconductor **33**. The OPC density detection sensor **70** is disposed higher than the black developer cartridge **35**K and includes a light source that emits light in the infrared region, a lens that irradiates the belt photoconductor **33** with the light, and a phototransistor that receives the light reflected from the belt photoconductor **33**.

The belt photoconductor electrostatic charger **45** is disposed below the belt photoconductor mechanism **31** and at upstream side of an irradiation position, at which the belt photoconductor **33** is exposed by the scanner unit **21**, with respect to the rotation direction of the belt photoconductor **33**, in the vicinity of the first belt photoconductor roller **39**. The belt photoconductor electrostatic charger **45** is disposed in confrontation with the belt photoconductor **33** with a predetermined spacing such that the belt photoconductor electrostatic charger **45** does not contact the belt photoconductor **33**.

The belt photoconductor electrostatic charger **45** is a scorotron charger that generates a corona discharge from a charge wire made of tungsten or the like, to charge the surface of the belt photoconductor **33** to a positive uniform charge.

The potential gradient controller **49** is positioned between the second belt photoconductor roller **41** and the first belt photoconductor roller **39** at a position higher than the black developer cartridge **35**K and contacts the foundation layer of the belt photoconductor **33**. The potential gradient controller **49** grounds the potential of the foundation layer at location where the potential gradient controller **49** contacts the foundation layer.

Next, printing operations of the color laser printer **1** will be described. The printing operations are performed by a microcomputer **110** shown in FIG. **2** controlling various components of the color laser printer **1**.

The topmost one of the recording sheets **5** accommodated in the sheet supply tray **11** of the sheet supply portion **7** is pressed by the sheet supply roller **13**, and the recording sheets **5** are extracted one at a time by the rotation of the sheet supply roller **13**. The extracted recording sheet **5** is supplied to the image forming position by the feed rollers **15** and the register rollers **17**. A predetermined registration is performed to the recording sheet **5** by the register rollers **17**. The belt photoconductor electrostatic charger **45** charges the surface of the belt photoconductor **33** to a uniform positive charge, and then the scanner unit **21** exposes the surface of the belt photoconductor **33** with the laser beam at a high-speed scanning based on image data. Because the charge at the exposed portion is erased (the charge on the surface moves to the foundation layer), a latent electrostatic image is formed on the surface of the belt photoconductor **33** as an arrangement of positively-charged portions and non-charged portions in accordance with the image data.

During this time, the first and third belt photoconductor rollers **39** and **43** supply power to the foundation layer of the belt photoconductor **33**, thereby maintaining the potential at the contact positions at ground level.

The yellow positioning solenoid **38**Y moves the yellow developer cartridge **35**Y horizontally rearward to bring the yellow developer roller **37**Y into contact with the belt photoconductor **33** on which the latent electrostatic image is formed.

The yellow toner contained within the yellow developer cartridge **35**Y has a positive charge so that the yellow toner adheres only to those parts on the belt photoconductor **33** that are not charged. As a result, a yellow visible toner image is formed on the belt photoconductor **33**.

During this time, the magenta developer cartridge **35**M, the cyan developer cartridge **35**C, and the black developer cartridge **35**K are moved horizontally forward by the corresponding positioning solenoids **38**M, **38**C, and **38**K, to keep the cartridges **35**M, **35**C, and **35**K separated from the belt photoconductor **33**.

When the yellow visible toner image on the belt photoconductor **33** reaches a position opposite the intermediate transfer belt **51** as the belt photoconductor **33** rotates, the yellow visible toner image is transferred onto the surface of the intermediate transfer belt **51**.

During this time, the potential applicator **47** applies the sequence bias of +300 V to the second belt photoconductor roller **41** by using the power source of the belt photoconductor electrostatic charger **45**. When that happens, the potential of the photosensitive layer in the vicinity of the second belt photoconductor roller **41** also reaches +300 V, through the conductive foundation layer of the belt photoconductor **33**. This generates a repulsion force between the positively charged yellow toner and the photosensitive layer, facilitating transfer of the yellow toner to the intermediate transfer belt **51**.

In the similar manner, a latent electrostatic image is formed on the belt photoconductor **33** for magenta, and a magenta visible toner image is formed on the belt photoconductor **33**. Then, the magenta visible toner image is transferred onto the intermediate transfer belt **51**.

That is, a latent electrostatic image is again formed on the belt photoconductor **33**. The magenta positioning solenoid **38**M moves the magenta developer cartridge **35**M horizontally rearward to bring the magenta developer roller **37**M into contact with the belt photoconductor **33** on which the latent electrostatic image is formed. At the same time, the yellow developer cartridge **35**Y, the cyan developer cartridge **35**C, and the black developer cartridge **35**K are moved horizontally forward by the corresponding positioning solenoids **38**Y, **38**C, and **38**K, to keep the cartridges **35**Y, **35**C, and **35**K separated from the belt photoconductor **33**. Accordingly, the magenta visible toner image is formed on the belt photoconductor **33** by the magenta toner alone supplied from the magenta developer cartridge **35**M. Then, the magenta visible toner image is transferred onto the intermediate transfer belt **51** when the toner image reaches the position opposite to the intermediate transfer belt **51**, so that the magenta image is superimposed on the previously transferred yellow visible toner image.

The above-described operations are repeated for the cyan toner contained within the cyan developer cartridge **35**C and the black toner contained within the black developer cartridge **35**K, so that a multicolor image is formed on the intermediate transfer belt **51**.

The multicolor image formed, on the intermediate transfer belt **51** is transferred all together onto the recording sheet **5** by the transfer roller **27** that is located at the transfer-enabling position, as the recording sheet **5** passes between the intermediate transfer belt **51** and the transfer roller **27**.

The heating roller **61** thermally fixes the multicolor image onto the recording sheet **5**, as the recording sheet **5** passes between the heating roller **61** and the pressure roller **63**. The recording sheet **5** with the color image fixed thereon is then fed to a pair of sheet delivery rollers by feed rollers **65**. Then, the recording sheet **5** is delivered by the sheet delivery rollers into a sheet delivery tray that is formed in an upper portion of the main casing **3**.

That is, a latent electrostatic image is formed by exposure every time the belt photoconductor **33** makes one revolution, and the latent electrostatic image is developed into a toner image. Then, the toner image is transferred onto the intermediate transfer belt **51** which is rotated in synchronization with the rotation of the belt photoconductor **33**. These operations are repeated four times for forming a multicolor image, which is formed of toner images of four colors superimposed one on the other, and then the full-color toner image is transferred onto the recording sheet **5**, thereby forming the multicolor image on the recording sheet **5**.

Next, a density detection operation will be described. The density detection operation is necessary for performing a color correction process (calibration). The color correction process is performed before the above-described printing operation for adjusting the density of each color to be used during printing operations by adjusting the pulse width of the laser beam, the voltages applied to each of the developer rollers **37** and the belt photoconductor electrostatic charger **45**, and the like. Note that the density detection operation is performed by the various components under the control of the microcomputer **110**.

FIG. **2** shows components that are necessary for the density detection operation, and all other components are summarized as other circuitry **50** in FIG. **2**. Descriptions of these other components are omitted.

The description first concerns a density detection operation performed by using the OPC density detection sensor **70** (hereinafter referred to as "first density detection operation").

FIG. **3** is a timing chart illustrating the first density detection operation. In this operation, density detection is performed for all of the yellow, magenta, cyan, and black (YMCK) colors in a first rotation of the belt photoconductor **33**, and all of the YMCK toners used in the density detection is recovered in a second rotation of the belt photoconductor **33**.

First, the transfer roller **27** is moved to the standby position. The sheet supply roller **13** is controlled not to rotate. The belt photoconductor **33** is then driven to rotate a total of two times, by the rotational drive of the second belt photoconductor roller **41** that is driven by the main motor **80** through the drive gear **82**. During this time, a recovery bias (reverse bias) of +300 V is applied to the first intermediate transfer belt roller **53**, thereby generating an electrical field that attracts toner from the intermediate transfer belt **51** towards the belt photoconductor **33**.

Then, the belt photoconductor electrostatic charger **45** charges the surface of the belt photoconductor **33** to a uniform positive charge. The scanner unit **21** exposes the surface of the belt photoconductor **33** with the scanning of the laser light, thereby forming latent electrostatic images corresponding to color correction processing patterns **91** shown in FIG. **4** while the belt photoconductor **33** rotates one time. In other words, latent electrostatic images corresponding to a yellow color correction processing pattern **91**Y, a magenta color correction processing pattern **91**M, a cyan color correction processing pattern **91**C, and a black color correction processing pattern

91K are sequentially formed on the belt photoconductor **33** while the belt photoconductor **33** rotates once. Each color correction processing pattern **91** has a region for solid color and a region for half-tone. The timings of these exposure operations correspond to the timings indicated by "Exposure" for the exposure Y, the exposure M, the exposure C, and the exposure K in the timing chart of FIG. **3**.

Here, as described above, the latent electrostatic image corresponding to the color correction processing patterns **91** is formed on the surface of the belt photoconductor **33** because the charge at the exposed portion is erased (moves to the foundation layer). At this time, the first and the third belt photoconductor rollers **39** and **43** maintain the potential of the foundation layer of the belt photoconductor **33** at the ground level.

The yellow positioning, solenoid **38**Y moves the yellow developer cartridge **35**Y horizontally to the rear so that the yellow developer roller **37**Y contacts the belt photoconductor **33** while the latent electrostatic image for the yellow color correction processing pattern **91**Y on the belt photoconductor **33** is positioned opposite the yellow developer cartridge **35**Y. Because the yellow toner contained within the yellow developer cartridge **35**Y has a positive charge, the yellow toner adheres only to those parts on the belt photoconductor **33** that are not charged. As a result, the yellow color correction processing pattern **91**Y, which is a yellow visible toner image, is formed on the belt photoconductor **33**.

In the same manner, the magenta positioning solenoid **38**M moves the magenta developer cartridge **35**M horizontally to the rear so that the magenta developer roller **37**M contacts the belt photoconductor **33** while the latent electrostatic image for the magenta color correction processing pattern **91**M on the belt photoconductor **33** is positioned opposite the magenta developer cartridge **35**M. Because the magenta toner contained within the magenta developer cartridge **35**M has a positive charge, the magenta toner adheres only to those parts on the belt photoconductor **33** that are-not charged. As a result, the magenta color correction processing pattern **91**M, which is a magenta visible toner image, is formed on the belt photoconductor **33**.

In the similar manner, the cyan positioning solenoid **38**C moves the cyan developer cartridge **35**C horizontally to the rear so that the cyan developer roller **37**C contacts the belt photoconductor **33** while the latent electrostatic image for the cyan color correction processing pattern **91**C on the belt photoconductor **33** is positioned opposite the cyan developer cartridge **35**C. Because the cyan toner contained within the cyan developer cartridge **35**C has a positive charge, the cyan toner adheres only to those parts on the belt photoconductor **33** that are not charged. As a result, the cyan color correction processing pattern **91**C, which is a cyan visible toner image, is formed on the belt photoconductor **33**.

In the similar manner, the black positioning solenoid **38**K moves the black developer cartridge **35**K horizontally to the rear so that the black developer roller **37**K contacts the belt photoconductor **33** while the latent electrostatic image for the black color correction processing pattern **91**K on the belt photoconductor **33** is positioned opposite the black developer cartridge **35**K. Because the black toner contained within the black developer cartridge **35**K has a positive charge, the black toner adheres only to those parts on the belt photoconductor **33** that are not charged. As a result, the black color correction processing pattern **91**K, which is a black visible toner image, is formed on the belt photoconductor **33**.

The timings of these development operations correspond to the timings indicated by "Development" for the development Y, the development M, the development C, and the development K in the timing chart of FIG. **3**.

In this manner, the different colors of toner adhere onto the belt photoconductor **33** during one rotation, thereby forming the color correction processing patterns **91**.

Then, the OPC density detection sensor **70** detects the density of each of the YMCK toner images (color correction processing patterns **91**Y, **91**M, **91**C, and **91**K) at the OPC density detection timings shown in FIG. **3** at a density detection sensor position **92** shown in FIG. **4**. Then, the OPC density detection sensor **70** outputs those densities to the microcomputer **110**.

In this manner, the density detection for all the YMCK colors completes within one rotation of the belt photoconductor **33**. In other words, conventional density detection is done while the belt photoconductor **33** rotates four times in a similar manner to that of printing as described previously. However, according to the present embodiment, the density detection completes within one rotation, so that density detection is performed rapidly.

Note that the color correction processing patterns **91** of this embodiment is formed within a range of the belt photoconductor **33** that is less than a range that is necessary for printing an image corresponding to the maximum sheet size that the color laser printer **1** can print upon. In addition, the total time during which the color developer rollers **37** are in contact with the belt photoconductor **33** during the formation of the color correction processing patterns **91** is shorter than the total time that the color developer rollers **37** have to be in contact with the belt photoconductor **33** during the printing of an image corresponding to the maximum sheet size that the color laser printer **1** can print upon.

Afterwards, as shown in FIG. **3**, the recovery bias, which is a reverse bias, is applied to the developer rollers **37** during the second rotation of the belt photoconductor **33**, so that toner is collected from the belt photoconductor **33** and stored into the toner storage portions.

More specifically, the yellow positioning solenoid **38**Y moves the yellow developer cartridge **35**Y horizontally to the rear so that the yellow developer roller **37**Y contacts the belt photoconductor **33** while the yellow color correction processing pattern **91**Y is positioned opposite to the yellow developer cartridge **35**Y. As a result, yellow toner forming the yellow color correction processing pattern **91**Y on the belt photoconductor **33** is attracted to the yellow developer roller **37**Y and recovered into the yellow developer cartridge **35**Y. During this time, the recovery bias of −200 V is applied to the yellow developer roller **37**Y.

In the same manner, the magenta positioning solenoid **38**M moves the magenta developer cartridge **35**M horizontally to the rear so that the magenta developer roller **37**M contacts the belt photoconductor **33** while the magenta color correction processing pattern **91**M is positioned opposite to the magenta developer cartridge **35**M. As a result, magenta toner forming the magenta color correction processing pattern **91**M on the belt photoconductor **33** is attracted to the magenta developer roller **37**M and recovered into the magenta developer cartridge **35**M. During this time, the recovery bias of −200 V is applied to the magenta developer roller **37**M.

In the similar manner, the cyan positioning solenoid **38**C moves the cyan developer cartridge **35**C horizontally to the rear so that the cyan developer roller **37**C contacts the belt photoconductor **33** while the cyan color correction processing pattern **91**C is positioned opposite to the cyan developer cartridge **35**C. As a result, cyan toner forming the cyan color correction processing pattern **91**C on the belt photoconductor **33** is attracted to the cyan developer roller **37**C and recovered into the cyan developer cartridge **35**C. During this time, the recovery bias of −200 V is applied to the cyan developer roller **37**C.

In the similar manner, the black positioning solenoid **38**K moves the black developer cartridge **35**K horizontally to the rear so that the black developer roller **37**K contacts the belt photoconductor **33** while the black color correction processing pattern **91**K is positioned opposite to the black developer cartridge **35**K. As a result, black toner forming the black color correction processing pattern **91**K on the belt photoconductor **33** is attracted to the black developer roller **37**K and recovered into the black developer cartridge **35**K. During this time, the recovery bias of −200 V is applied to the black developer roller **37**K.

The timings of these recovery operations correspond to the timings indicated by "Recovery" for the development Y, the development M, the development C, and the development K in the timing chart of FIG. **3**. This makes it possible to recover the different colors of toner back into the respective developer cartridges **35** during the second rotation of the belt photoconductor **33**.

In this manner, the toner used in the density detection is recovered without being wasted, enabling the implementation of more efficient density detection.

After the above-described density detection, the microprocessor performs the color correction process based on the detection results. Since the color correction process is well known in the art, description thereof is omitted.

Next, a density detection operation performed by using the ITB density detection sensor **71** (hereinafter referred to as "second density detection operation") will be described.

FIG. **5** shows a timing chart illustrating the second density detection operation. In this operation, the color correction processing patterns **91** is formed on the belt photoconductor **33** by performing the exposure and developing operations in the similar manner as in the above-described first density detection operation. In addition, in this operation, the sequence bias is applied to the second belt photoconductor roller **41** so as to transfer the color correction processing patterns **91** from the belt photoconductor **33** onto the intermediate transfer belt **51**, and then the color correction processing patterns **91** transferred on the intermediate transfer belt **51** is detected by the ITB density detection sensor **71**.

Accordingly, the density detection of all the YMCK colors completes during the first half of the second rotation of the intermediate transfer belt **51**, as shown at "timing of density detection on ITB" in FIG. **5**.

Also, after the transfer of the color correction processing patterns **91** from the belt photoconductor **33** onto the intermediate transfer belt **51** has completed, the transfer bias to the second belt photoconductor roller **41** is switched to the reverse bias, so that the color correction processing patterns **91** on the intermediate transfer belt **51** is transferred back to the belt photoconductor **33**.

Then, the different colors of toner that is forming the color correction processing patterns **91** on the belt photoconductor **33** are recovered back into the corresponding developer cartridges **35**, in the same manner as in the above-described first density detection operation.

In this manner, exposure, development, density detection, and toner recovery for each color are performed at the timings shown in FIG. **5**. That is, the density detection is completed within two rotations of the intermediate transfer belt (ITB) **51**, and toner recovery is completed within three rotations of the intermediate transfer belt **51**.

Conventional density detection is done while the intermediate transfer belt **51** rotates four times in a similar manner to that of printing. However, according to the present embodiment, the density detection completes within two rotations of the intermediate transfer belt **51**. Accordingly, density detection is performed rapidly. Also, the toner used in the density detection can be recovered without being wasted, enabling the implementation of more efficient density detection.

Moreover, because density of each color correction processing pattern **91** which has been transferred onto the intermediate transfer belt **51** is detected, calibration can be performed with taking the transfer efficiency between the belt photoconductor **33** and the intermediate transfer belt **51** into consideration. Because the density detection is performed at portions close to the position where toner images are transferred onto a recording sheet **5**, the accuracy of the calibration can be increased.

It should be noted that in the above-described first embodiment, the four-color color laser printer **1** was used as an example of a color laser printer. However, the color laser printer could be any color laser printer that uses n colors (where n is an integer of at least 2), such as two colors or six colors.

Also, although in the above-described first embodiment the color laser printer **1** was used as an example of an image forming device, the image forming device could be other devices, such as a multifunction device having the function of such a color laser printer, a facsimile machine, or the like.

In the first embodiment, the toner used for the density detection operation was recovered into the developer cartridges **35**. However, the toner used for the density detection operation could be collected by a cleaner **22** (see FIG. **1**) that is disposed downstream of a position, where the belt photoconductor **33** and the intermediate transfer belt **51** contact each other, with respect to the rotational direction of the belt photoconductor **33** and upstream of a position, where the belt photoconductor **33** and the belt photoconductor electrostatic charger **45** confront each other with respect to the rotational direction of the belt photoconductor **33**.

For example, the cleaner **22** could include a cleaning box, a cleaning roller, a removal roller, and a cleaning blade. The cleaning box has a box shape having a lower space therein, and is formed with an opening formed in a part of the side that faces the belt photoconductor **33**. The cleaning roller is formed of a metal roller body covered with an elastic body of silicone rubber. The cleaning roller is rotatably supported in the opening of the cleaning box and is disposed facing the belt photoconductor **33**. The cleaning roller is applied with a predetermined cleaning bias with respect to the belt photoconductor **33**. The removal roller is formed of a metal roller and is disposed within the cleaning box on the opposite side of the cleaning roller from the belt photoconductor **33**, in contact with the cleaning roller. The removal roller is applied with a predetermined removal bias with respect to the cleaning roller. The cleaning blade is disposed inside the cleaning box on the opposite side of the removal roller from the cleaning roller, so as to be pressed into contact with the removal roller. The cleaning blade is a scraping blade having a thin-plate shape.

After the density detection completes, the toner that is forming the color correction processing patterns **91** on the belt photoconductor **33** is electrically attracted to and captured by the cleaning roller when the toner is brought opposite to the cleaning roller by the rotation of the belt photoconductor **33**. The toner captured by the cleaning roller is subsequently electrically captured by the removal roller when the rotation of the cleaning roller brings the toner opposite to the removal roller. Then, the toner is subsequently scraped off by the cleaning blade and collected in the lower space of the cleaning box.

With this configuration, the toner can be removed from the belt photoconductor **33** immediately after the density detection, although the toner cannot be reused. Accordingly, the density detection can be performed faster than the case in which the toner is reclaimed into the developer cartridges **35**.

Next, a second embodiment of the present invention will be described. In this embodiment, a tandem-type color laser printer **201** shown in FIG. **6** is described as an example of the image forming device.

As shown in FIG. **6**, the color laser printer **201** includes a visible image forming portion **204**, a belt-shaped intermediate transfer body (ITB) **205**, a fixer portion **208**, a supply portion **209**, and a discharge tray **210***b*.

For each step in forming visible images with toner of the colors magenta (M), cyan (C), yellow (Y), and black (Bk), the visible image forming portion **204** includes developing units **251**M, **251**C, **251**Y, and **251**Bk (collectively referred to as "developing units **251**"), drum photoconductors **203**M, **203**C, **203**Y, and **203**Bk (collectively referred to as "drum photoconductors **203**"), cleaning rollers **270**M, **270**C, **270**Y, and **270**Bk (collectively referred to as "cleaning rollers **270**"), charging units **271**M, **271**C, **271**Y, and **271**Bk (collectively referred to as "charging units **271**"), and exposure devices **272**M, **272**C, **272**Y, and **272**Bk (collectively referred to as "exposure devices **272**").

The aforementioned components will be described in greater detail. The developing unit **251**M will be described first. Note that since the developing units **251**M, **251**C, **251**Y, and **251**Bk are identical, only the developing unit **251**M will be described, and description of the developing units **251**C, **251**Y, and **251**Bk will be omitted to avoid duplication in explanation.

The developing unit **251**M includes a developing roller **252**M, a supply roller **253**M, a thickness-regulating blade **254**M, and a developing case **255**. The developing roller **252**M is formed in a cylindrical shape with a conductive silicon rubber as the base material, the surface of which is coated with a resin or a rubber material containing fluorine. However, the developing roller **252**M need not be configured of a conductive silicon rubber as the base material, but instead may be configured of a conductive urethane rubber. The average roughness (Rz) at ten points on the surface of the developing roller **252**M should be set to 3-5 μm in order to be smaller than the average particle size of toner, which is 9 μm.

The supply roller **253**M is formed of a conductive sponge roller and is configured to contact the developing roller **252**M with pressure applied by the elastic force of the sponge. The supply roller **253**M can be configured of an appropriate foam member formed of a conductive silicon rubber, EPDM, or urethane rubber.

A base end of the thickness-regulating blade **254**M is formed of stainless steel to a plate shape and fixed to the developing case **255**M. A free end of the thickness-regulating blade **254**M is formed of an insulating silicon rubber or an insulating rubber or synthetic resin containing fluorine. The free end of the thickness-regulating blade **254**M contacts the developing roller **252**M from the bottom side.

The developing case **255**M accommodates toner which is a positively charging nonmagnetic single-component developer. The toner includes base toner particles having an average size of 9 μm. The base toner particles are formed by adding an additive, such as carbon black, well known in the art and a charge-controlling agent or charge-controlling resin, such as nigrosine, triphenylmethane, or quaternary ammonium salt, to a styrene-acrylic resin formed in a spherical shape through suspension polymerization. The toner is configured by adding silica to the surface of the base toner particles. The silica additive undergoes hydrophobing according to a process known in the art using a silane coupling agent, silicon oil, or the like. The average particle size of the silica is 10 nm, with the additive accounting for a 0.6% of the base toner particle weight. Toner of the colors magenta, cyan, yellow, and black are accommodated in the developing cases **255**M, **255**C, **255**Y, and **255**Bk, respectively.

The toner is a suspension polymerized toner very nearly spherical in shape. Also, the hydrophobed silica having an average particle size of 10 nm has been added to the particles at 0.6% weight. Therefore, the toner has excellent fluidity, and a sufficient charge amount can be obtained by tribocharging. Further, since the toner has no sharp edges like coarsely ground toner, the particles are less affected by mechanical forces and readily follow the electric field, thereby achieving efficient transfer.

The drum photoconductors **203** are formed, for example, of an aluminum base covered by a positively charged photosensitive layer. The photosensitive layer is formed at a thickness of 20 μm or greater. Further, the aluminum base is used as a grounding layer.

The cleaning rollers **270** are formed of conductive materials, such as a conductive sponge, and are disposed below the corresponding drum photoconductors **203** in sliding contact with the same. A power source not shown in the drawings applies a voltage of negative polarity, which is the opposite polarity from the toner, to the cleaning rollers **270**. The cleaning rollers **270** remove residual toner on the drum photoconductors **203** by the frictional force on the drum photoconductors **203** and the effects of the electric field generated by the above voltages. Since the present embodiment employees a cleanerless developing method, residual toner removed from the cleaning rollers **270** is once again returned to the drum photoconductors **203** and further to the developing units **251** via the developing rollers **252** within a prescribed cycle after the developing process has been completed.

The charging units **271** are Scorotron-type charging devices and confront the surfaces of the drum photoconductors **203** from the bottoms thereof at positions downstream of the cleaning rollers **270** in the rotational direction of the drum photoconductors **203** so as to not contact the surface of the drum photoconductors **203**.

The exposure devices **272** are each configured of a laser scanner unit well known in the art. The exposure devices **272** are disposed in vertical alignment with the developing units **251** and also in alignment with the drum photoconductors **203** and the charging units **271** in the horizontal direction.

The exposure devices **272** irradiate laser light based on image data onto the surfaces of the drum photoconductors **203** at positions downstream from the charging units **271** in the rotational direction of the drum photoconductors **203** so as to form latent electrostatic images for each color on the surfaces of the drum photoconductors **203**.

The toner is positively charged, supplied from the supply roller **253**M, **253**C, **253**Y, **253**Bk to the developing roller **252**M, **252**C, **252**Y, **252**Bk, and formed to a uniform layer of thin thickness by the thickness-regulating blade **254**M, **254**C, **254**Y, **254**Bk. This construction effectively develops positively charged latent images formed on the drum photoconductors **203** with the positively charged toner according to a reverse developing method in which the positively-charged toner is attracted to negatively-charged areas of the drum photoconductors **203** at points of contact between the developing rollers **252** and the drum photoconductors **203**, thereby forming an image of very high quality.

The intermediate transfer body **205** is a conductive sheet formed of polycarbonate, polyimide, or the like that is configured in a belt shape. The intermediate transfer body **205** is looped around two drive rollers **260** and **262**. Intermediate transfer rollers **261**M, **261**C, **261**Y, and **261**Bk are disposed near positions opposing the drum photoconductors **203**. The surface of the intermediate transfer body **205** on the side opposing the drum photoconductors **203** moves vertically downward as shown in FIG. **6**.

A prescribed voltage is applied to the intermediate transfer rollers **261** in order to transfer toner deposited on the drum photoconductors **203** to the intermediate transfer body **205**. A secondary transfer roller **263** is disposed at the position in which the toner image is transferred to a paper P, that is, opposite the drive roller **262** disposed at the lower end of the intermediate transfer body **205**. A prescribed potential is applied to the secondary transfer roller **263**, so that a four-color toner image carried on the intermediate transfer body **205** is transferred onto the paper P.

As shown in FIG. **6**, a cleaning unit **206** is disposed on the opposite side of the intermediate transfer body **205** from the drum photoconductors **203**. The cleaning unit **206** includes a scraping device **265** and a case **266**. Toner remaining on the intermediate transfer body **205** is scraped off by the scraping device **265** and accumulates in the case **266**. Note that during the color correcting process, the cleaning unit **206** is not used.

The fixer portion **208** includes first and second heating rollers **281** and **282**. A paper P carrying a four-color toner image is heated and compressed by the first and second heating rollers **281** and **282** while being conveyed therebetween, thereby fixing the toner image to the paper P.

The supply portion **209** is disposed on the bottom of the printer **201** and includes a loading tray **291** for accommodating the stacked paper P and a pickup roller **292** for feeding the paper P. The supply portion **209** feeds the paper P at a prescribed timing in relation to the image forming process performed by the exposure devices **272**, the developing units **251**, the drum photoconductors **203**, and the intermediate transfer body **205**. A pair of conveying rollers **300** conveys the paper P fed by the supply portion **209** to the nip point between the intermediate transfer body **205** and the secondary transfer roller **263**.

An upper cover **210** is rotatably supported at the uppermost portion of the device by a shaft **210***a*. A portion of the upper cover **210** serves as the discharge tray **210***b*. The discharge tray **210***b* is disposed at the discharge end of the fixer portion **208**. The discharge tray **210***b* accommodates paper P discharged from the fixer portion **208** and conveyed by pairs of conveying rollers **301**, **302**, and **303**.

A front cover **220** is configured to swing open about a shaft **220***a* in the direction indicated by an arrow in FIG. **6**. By opening the front cover **220**, the developing units **251** can be easily replaced. Springs **221**M, **221**C, **221**Y, and **220**Bk are provided to the front cover **220** at positions confronting the developing units **251**. When the front cover **220** is closed, the springs **221**M, **221**C, **221**Y, and **220**Bk press the developing units **251** rearward (to the left in FIG. **6**).

Next, printing operations of the printer **201** according to the present embodiment will be described. First, the charging units **271** apply a uniform charge to the photosensitive layers on the drum photoconductors **203**. Next, these photosensitive layers are exposed to the exposure devices **272** based on image data for the colors magenta, cyan, yellow, and black, thereby forming latent electrostatic images. The developing units **251**M, **251**C, **251**Y, and **251**Bk deposit magenta toner, cyan toner, yellow toner, and black toner on the latent electrostatic images formed on the photosensitive layers of the corresponding drum photoconductors **203** to develop the magenta, cyan, yellow, and black colors of the image. The toner images in magenta, cyan, yellow, and black that formed in this way are transferred onto the surface of the intermediate transfer body **205**. The toner image for each color is formed at slightly different times with consideration for the velocity of the intermediate transfer body **205** and the positions of the drum photoconductors **203** in order to superimpose the toner images of each color on the intermediate transfer body **205**. In this manner, a multicolor toner image is formed on the intermediate transfer body **205**.

Toner remaining on the drum photoconductors **203** following the transfer is temporarily retained by the cleaning rollers **270**.

The multicolor toner image formed on the intermediate transfer body **205** is then transferred to the paper P fed from the supply portion **209** at the nip point between the secondary transfer roller **263** and the intermediate transfer body **205**. After the toner image is fixed to the paper P in the fixer portion **208**, the paper P is discharged onto the discharge tray **210***b*. Hence, a multicolor image is formed on the paper P.

The description now turns to density detection operation that is performed for the color correction process (calibration) for adjusting the density of each color to be used during printing, by adjusting the voltages applied to the developer rollers **252** before the above-described forming (printing) of the color image.

FIG. **7** shows a timing chart illustrating the density detection operation according to the present embodiment. IN the embodiment, the density detection operation is performed by using a density detection sensor **400**. The density detection sensor **400** is disposed on the upstream side of the portion at which the intermediate transfer body **205** faces the cleaning device **206** at a position to the side of the intermediate transfer body **205** and opposite to the intermediate transfer body **205**. The density detection sensor **400** detects the density of each of the CMYK colors on the intermediate transfer body **205** at a similar position to the density detection sensor position **92** shown in FIG. **4**.

During the density detection operation, exposure and development are performed at the timings shown in FIG. **7** during the first rotation of the intermediate transfer body **205** in a similar manner to that of printing described previously so as to form the color correction processing patterns **91** shown in FIG. **4** within a region for one rotation of the intermediate transfer body **205**. Note that unlike during the printing operations, the color correction processing patterns **91**Y, **91**M, **91**C, **91**K are transferred to mutually different positions of the intermediate transfer body **205** without being superimposed one on the other. Then, the density detection sensor **400** detects the density of each of the YMCK toner images (color correction processing patterns **91**Y, **91**M, **91**C, and **91**K) at the "timing of density detection on intermediate transfer body" shown in FIG. **7**. In this manner, the density detection for all the YMCK colors completes within one rotation of the intermediate transfer body **205**.

During the second rotation of the intermediate transfer body **205**, a reverse bias is applied to the transfer rollers **261** while the corresponding color correction processing patterns **91** (**91**M, **91**C, **91**Y, **91**Bk) on the intermediate transfer body **205** are at positions opposite to the corresponding drum photoconductors **203**, so that the toner of the color correction processing patterns **91** on the intermediate transfer body **205** is transferred back onto the corresponding drum photoconductors **203**. The reverse bias could be ×1000 V for example.

During this time, ×400 V is applied to the cleaning rollers **270**, so that toner of each color on the drum photoconductor **203** is recovered by corresponding one of the cleaning rollers **270**. The timings of these recovery operations correspond to the timings indicated by "Recovery" for the development Y, the development M, the development C, and the development K in the timing chart of FIG. **7**.

Afterwards, at appropriate timings, the toner recovered by the cleaning rollers **270** is recovered into the respective developing cases **255** via the drum photoconductors **203**.

Accordingly, the toner used in the density detection operation can be recovered without being wasted, enabling the implementation **6**f more efficient density detection operation.

As described above, according to the above-described embodiments, a density detection operation can be performed efficiently, thus shortening the time required for density detection operation. Therefore, in an image forming device in which printing starts only after the color correction process, the time taken until the printing operation starts can be shortened.

While some exemplary embodiments of this invention have been described in detail, those skilled in the art will recognize that there are many possible modifications and variations which may be made in these exemplary embodiments while yet retaining many of the novel features and advantages of the invention.

What is claimed is:

1. An image forming device comprising:

a plurality of photoconductors each corresponding to one of a plurality of colors;

a plurality of exposure units, each of the exposure units forming a latent electrostatic image on a corresponding one of the photoconductors;

a plurality of developing units each corresponding to one of the plurality of colors, each of the developing units developing the latent electrostatic image formed on the corresponding one of the photoconductors into a developer image;

an image support member that supports the developer image;

a transfer unit that transfers the developer images each developed by one of the developing units onto the image support member; and

a density detector that detects a density of the developer image, wherein

during printing, the transfer unit transfers the developer images in each of the plurality of colors such that the developer images are superimposed on the image support member thereby to produce a multicolor image; and

during density detection, the transfer unit transfers the developer images in each of the plurality of colors to mutually different positions of the image support member within a range of the image support member that is less than a range necessary for printing an image corresponding to a maximum sheet size upon which the image forming device is capable to print, and the density detector detects the density of each developer image supported on the image support member.

2. The image forming device according to claim **1**, wherein each of the plurality of developing units recovers corresponding color of developer on the image support member after the density detector detects the density of each developer image during density detection.

3. The image forming device according to claim **1**, wherein the controller executes a color correction process based on detection results of the density detector.

4. The image forming device according to claim **1**, further comprising a recovery member that recovers developer to dispose the developer.

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